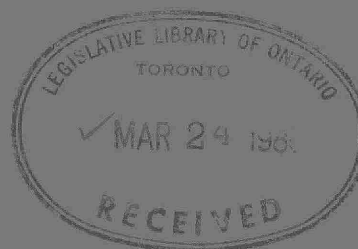


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BACTERIOLOGICAL STUDIES OF THE  
LAKE ERIE NEARSHORE AND  
EMBAYMENTS (1973) AND THE MOUTH  
OF THE GRAND RIVER (1975-76)



Ontario

Ministry  
of the  
Environment

The Honourable  
Harry C. Parrott, D.D.S.,  
Minister

Graham W. S. Scott,  
Deputy Minister

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~~GENERAL RWD~~Water quality

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BACTERIOLOGICAL WATER QUALITY OF  
LAKE ERIE NEARSHORE WATERS, 1973

G. JENKINS, M. YOUNG

AND G. HORSNELL.

MICROBIOLOGY SECTION  
LABORATORY SERVICES BRANCH  
MINISTRY OF THE ENVIRONMENT

APRIL 1978

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ABSTRACT

Three surveys of the Canadian nearshore waters of Lake Erie were carried out in 1973 in order to determine the bacteriological quality of these waters. Most of the nearshore waters are of relatively good quality, with the exception of certain embayment areas and harbours (e.g. Wheatley Harbour). Significantly elevated levels of all bacterial parameters were found near the mouth of the Detroit River in all three surveys, with the highest levels being detected in September.

LAKE ERIE - 1973Introduction

Three surveys of the Ontario shoreline of Lake Erie were conducted in 1973 as part of the Ontario Ministry of the Environment programs to monitor Great Lakes water quality. The survey area is geographically broken into three regions, the western basin which stretches from the Detroit River mouth to Point Pelee, the central basin from Point Pelee to the Grand River, and the eastern basin from the Grand River to the Niagara River.

The Detroit River is the major tributary flowing into Lake Erie, and the only other major river entering the lake along the Ontario shoreline is the Grand River. Numerous small towns and ports are situated along the Ontario shoreline, but there are no major cities or urban population centres. The major industrial centres are Leamington, where canning industries are located, and Wheatley where Omstead fisheries is situated.

Methods:

## Field Procedures:

Three surveys of the lake were conducted during the summer of 1973. The first survey ran from June 2 - 16, the second from July 17 - Aug 4, and the third from Sept. 5 - 17.

In each survey, the western and eastern basins were sampled in triplicate runs, during which time samples were collected at predesignated stations on each of three consecutive surveying days. Single samples were collected at stations located in the central basin from Wheatley to Port Maitland.

The stations that were monitored were chosen along the shoreline with particular bias towards sources of input (outfalls, rivers, etc.) Surface samples were collected at each station, while depth samples were collected at 76 stations. Surface samples were collected at approximately 1.5 meters below the surface of the lake while depth samples were taken at the mid-hypolimnion. All samples were collected in sterile 237 ml evacuated rubber syringes using a modified piggy-back sampler. The samples were immediately put on ice and transported to either the London M.O.E. laboratory or the Toronto M.O.E. laboratory for analysis.

#### Laboratory Methods:

When the samples arrived at the laboratory, they were transferred aseptically to sterile 250 ml polycarbonate bottles and analyzed within 24 hrs. of sampling. Analyses for total coliforms (TC), fecal coliforms (FC), and fecal streptococci (FS) using the membrane filtration technique as described in Standard Methods (13th edition) (1) were performed using m-Endo agar LES (Difco) for TC, MacConkey membrane broth (Oxford) for FC, and M-enterococcus agar for FS.

#### Statistical Methods:

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The large amounts of data generated from these surveys

require that statistical methods be utilized to summarize the results concisely and to facilitate an unbiased interpretation.

Once the station group statistics had been obtained, an analysis of variance program (ANOVA) was used to group the stations into areas within the same statistical bacterial level. The ANOVA analyses were first performed on all survey stations. If the calculated F-ratio was less than the critical F-ratio (0.05 level), the stations were considered statistically the same and were summarized as a group with one set of overall group statistics. At the same time as the ANOVA analyses were performed, the homogeneity of the variance was also checked using Bartlett's  $X^2$  test of homogeneity. If either the F or  $X^2$  values were significant, then stations were withdrawn until both were non-significant. The statistics were then repeated on the withdrawn stations until all stations had been properly grouped.

Criteria:

The criteria considered permissible for public surface water supplies when full treatment is supplied for the three sanitary indicator bacteria; total coliforms, fecal coliforms, and fecal streptococci are a maximum geometric mean of 5000, 500 and 50 per 100 ml respectively. The maximum permissible levels for private water supplies requiring chlorination only are 100, 10, and 1 per 100 ml respectively, while that for waters requiring chlorination and filtration are 400, 40, and 4 per 100 ml.

The Recreational Use Criteria states that "Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100, and/or 20 per 100 ml respectively....". The geometric mean of FS results is mainly used in a ratio with the

corresponding FC geometric mean (FC/FS) to gain information on the source (Human or non-human) of pollution within areas adjacent to or at an input. If this ratio is greater than 4.0, the source is most likely of human origin(2). It should be noted that this ratio is used to determine the source of pollution and not the safety of the water as animals are a potential source of organisms pathogenic to humans.

#### RESULTS:

During the June survey, elevated TC and FC levels were found at the mouth of the Detroit River. The TC level of 927/100 ml dropped rapidly with distance away from the mouth, and the levels throughout most of the western basin were much lower (Map 1). The FC concentration of 59/100 ml at the mouth of the Detroit River dropped to less than 3/100 ml for the remainder of the western basin except for Wheatley Harbour where extremely high levels of all three bacterial parameters were found. The TC, FC and FS concentrations at that location were 15700, 465 and 567/100 ml respectively, exceeding M.O.E. criteria. The FS density for the rest of the western basin was <3/100 ml.

Slightly elevated TC levels (236/100) were detected in Pigeon Bay near Leamington, and one isolated area in this region had a TC level of 2850/100 ml. The location did not have significantly elevated FC or FS levels.

The central basin exhibited very low bacterial levels. The TC concentration for the region from Wheatley to Port Maitland was 9/100 ml while the FC and FS concentrations were each <2/100 ml.

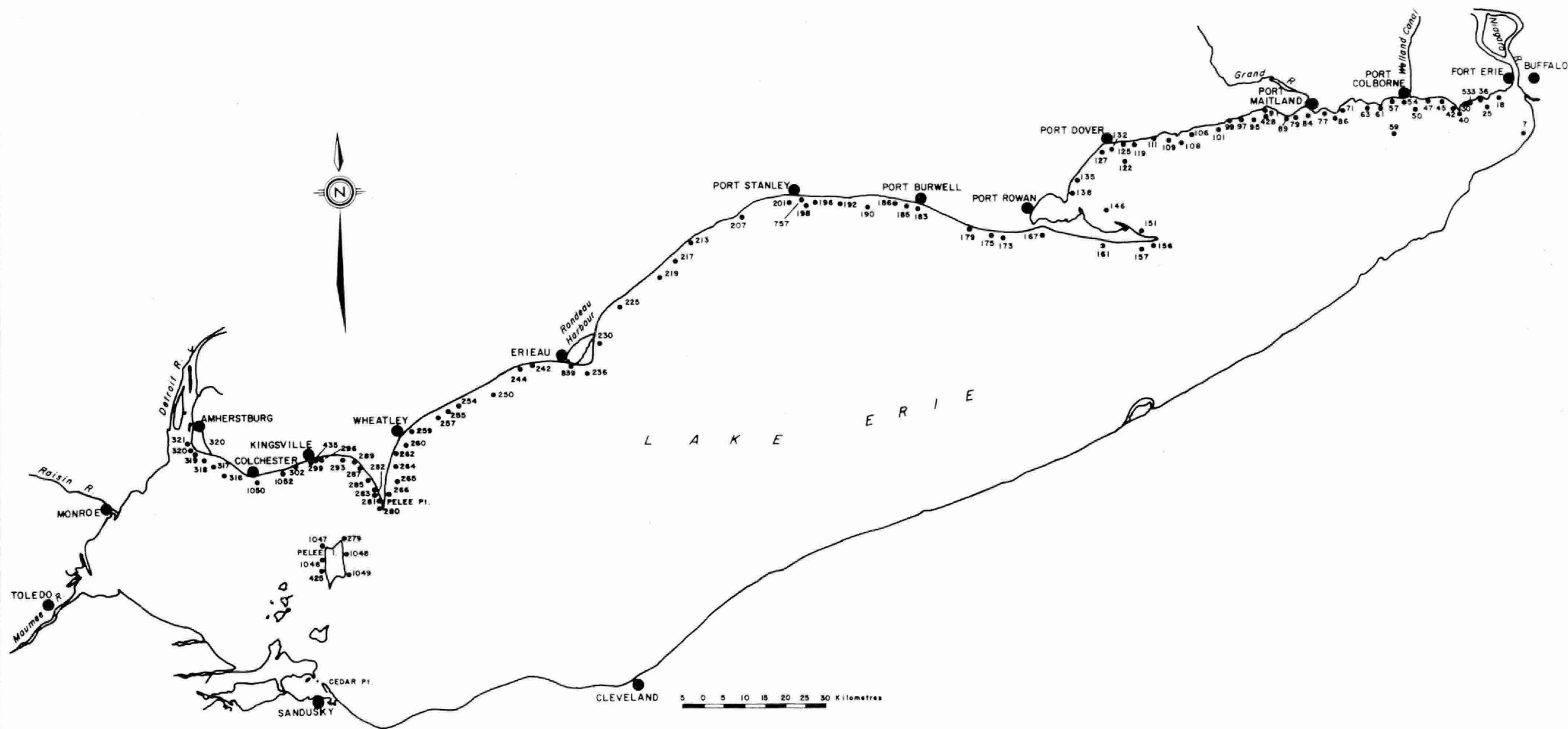
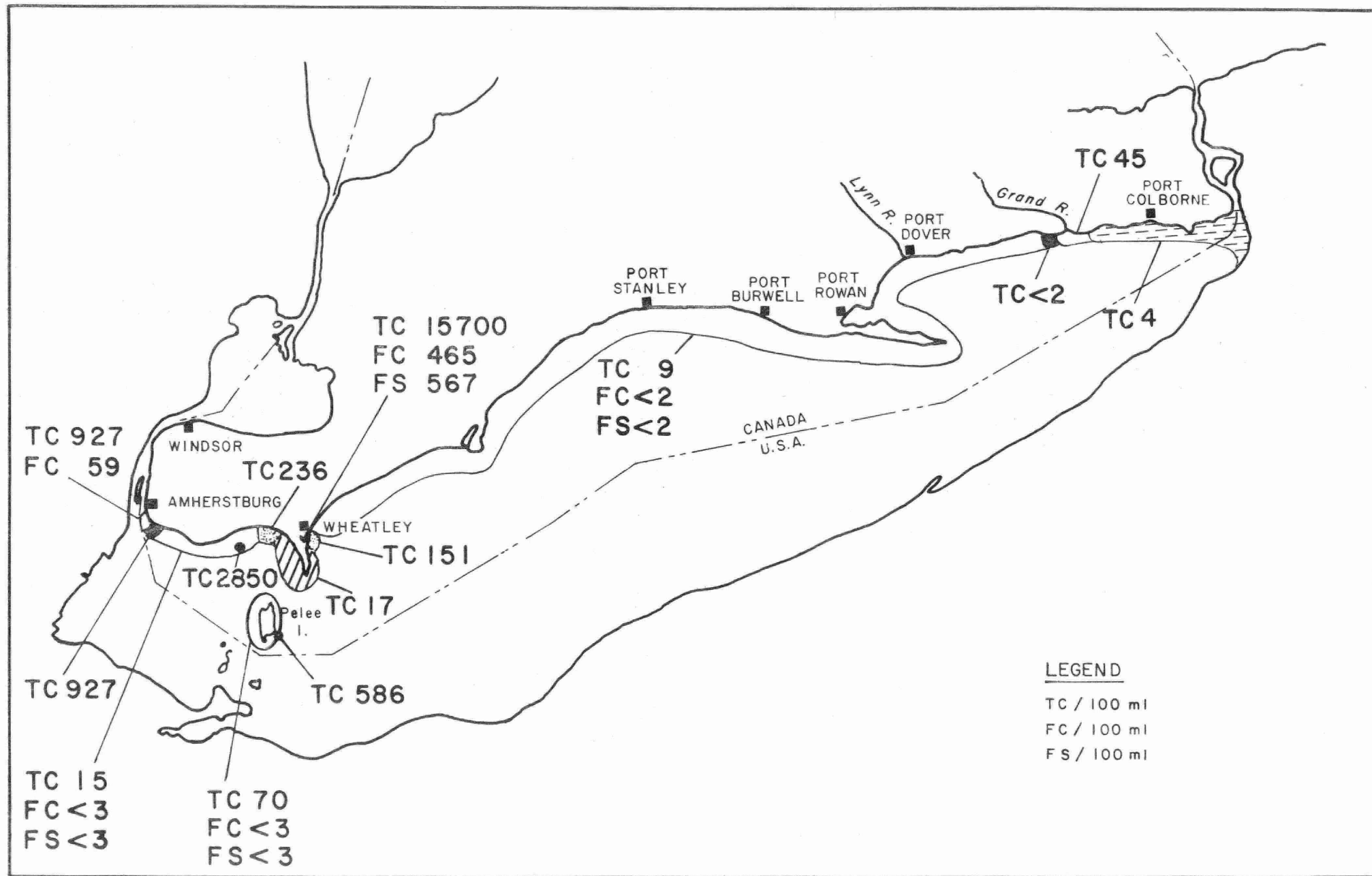
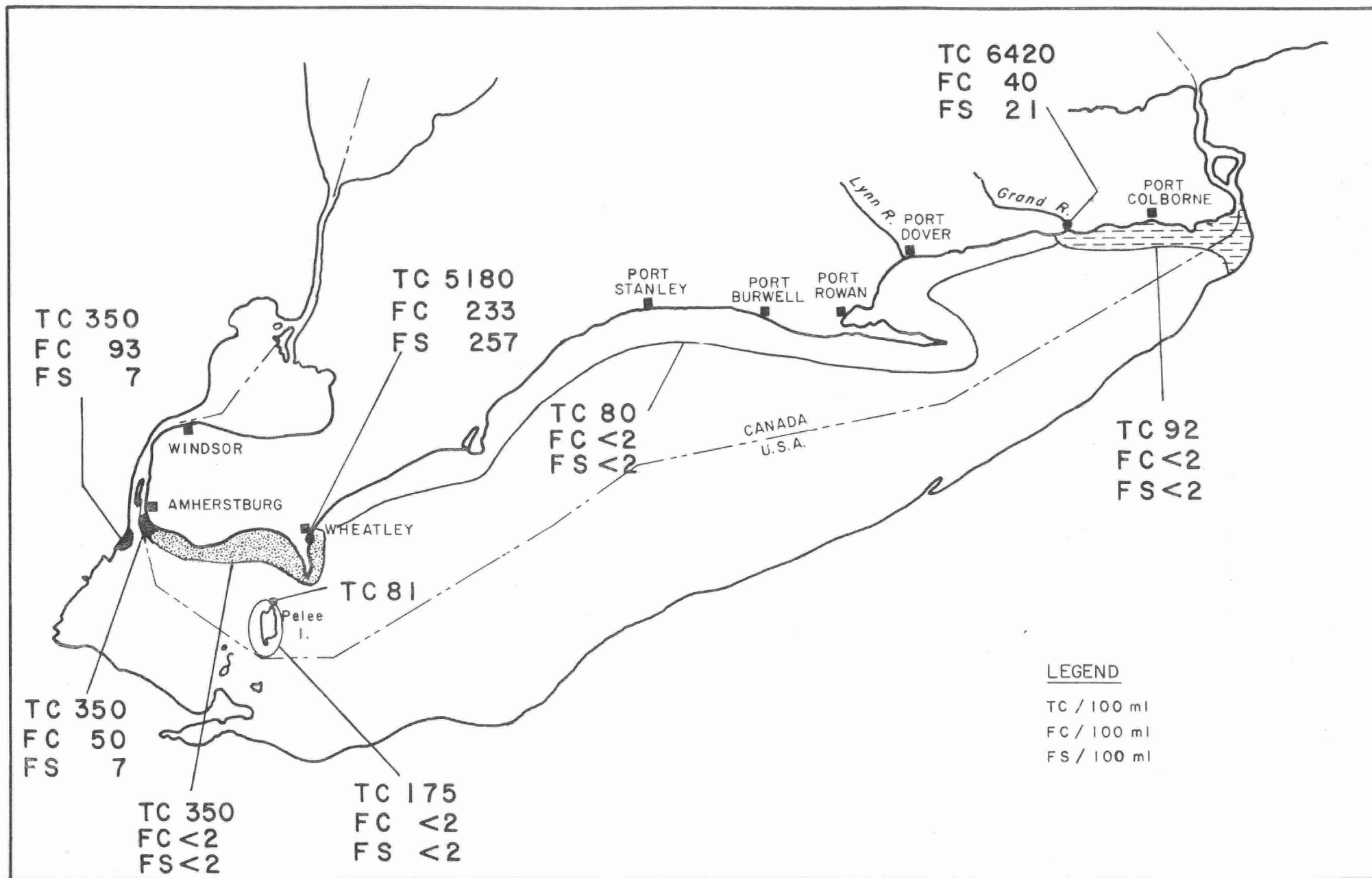


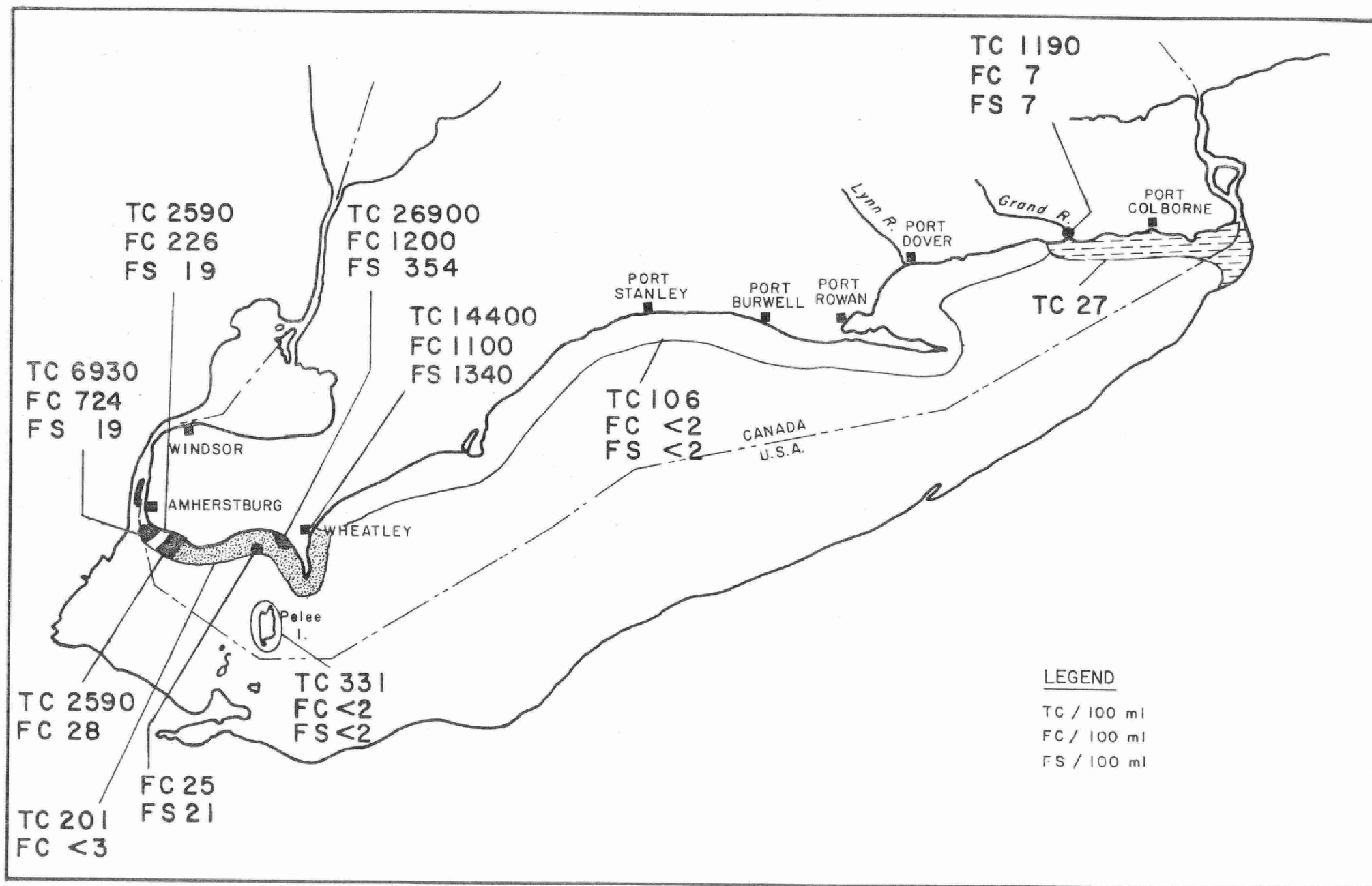
FIGURE 1: LAKE ERIE SAMPLING POINTS 1973



MAP 1 : LAKE ERIE - JUNE, 1973



MAP 2 : LAKE ERIE - JULY, 1973



MAP 3 : LAKE ERIE - SEPTEMBER, 1973

In the eastern basin, TC levels rose slightly to 45/100 ml just east of the Grand River and then dropped to 4/100 ml for the rest of the eastern basin. FC and FS densities were <2/100 ml throughout this region.

In the July survey, the entire western basin had a TC level of 350/100 ml (Map 2). High FC levels were found at the mouth of the Detroit River where 93/100 ml were detected near the U.S. shore and 50/100 ml were detected near the Canadian shore. The FS levels here were 7/100 ml. The rest of the western basin had FC and FS concentrations <2/100 ml.

Elevated TC, FC, and FS levels were once again detected in Wheatley Harbour, being 5180, 233 and 257/100 ml respectively. In the central basin, the TC concentration was 80/100 ml in July, while the FC and FS concentrations were <2/100 ml.

The eastern basin had a TC level of 92/100 ml during the July survey, while the FC and FS concentrations were each <2/100 ml. The only location with higher levels was at the mouth of the Grand River where TC, FC, and FS levels of 6420, 40 and 21/100 ml respectively were detected.

In the September survey, very high coliform densities were detected at the mouth of the Detroit River (Map 3). The TC concentration was 6930/100 ml while the FC concentration was 724/100 ml. These levels gradually declined with distance from the river mouth.

Elevated bacterial levels were detected near the W.P.C.P. outfall at Leamington. Here, the TC, FC, and FS levels were 26900, 1200, and 354/100 ml respectively. Very high levels were also detected at Wheatley, where the TC, FC, and FS concentrations were 14400, 1100, and 1340/100 ml respectively.

In the central basin, the TC concentration was 106/100 ml in September, while the FC and FS levels were <2/100 ml.

The FC and FS levels in the eastern basin were also <2/100 ml while the TC level was 27/100 ml. The only location with elevated bacterial densities was at the mouth of the Grand River where 1190 TC/100 ml were detected,

#### Discussion:

Bacterial levels along the main portion of the Canadian shoreline of Lake Erie are generally quite low and well within criteria limits. However, a few isolated areas of concern are evident in the western and eastern basins.

The Detroit River is the major influence on the bacterial water quality of the western basin. The Detroit River is the recipient body for inadequately treated municipal waste. The extent of this problem was illustrated in September by the very high bacterial levels at the mouth of the river, a few miles downstream from the closest major pollution source, namely the S.T.P. outfall from Amherstburg.

Degraded water quality was also evident in September in Pigeon Bay near Leamington, with inadequately treated municipal waste being the suspected source. This outfall is a combined outfall that receives waste from the Pyramid Canning Co., as well as separately treated wastes from the H.J. Heinz Canning Co. and

this may also be a contributing factor to the quality of the effluent. August and September are peak canning times, and it appears that the W.P.C.P. is overloaded at that time. Its facilities only consisting of primary treatment at the time of the survey.

Elevated bacterial levels were detected in Wheatley Harbour during all three survey periods. These levels were above Recreational Use Criteria every survey and exceeded Public Surface Water Supplies Criteria for each parameter in September, and for at least one parameter in each of the other surveys. This is of special concern as the municipal water intake is close to the sampling location. The FC/FS ratio was less than 1.0 in each survey, and the source of the bacterial loadings appears to be the effluent from Omstead Fisheries (3).

The central basin is predominately free of major input sources and no problem areas were detected in any of the surveys.

The only other input of note was the Grand River in the eastern basin. TC levels at the mouth exceeded Recreational Use Criteria in July and September, but the extent of the degradation appeared to be quite localized.

## References:

1. Standard Methods for the examination of Water and Wastewater, 13th Edition. Edited by M.J. Tarus, A.E. Greenberg, R.D. Haak and M.C. Rand. A.P.W.A. AWWA. W.P.C.F. pp. 635-693.
2. Geldreich, E.E. and Kenner, B.A. 1969. Concepts of fecal streptococci in stream pollution. Journal W.P.C.F. 41, R336-352.
3. Jenkins, G.D. and G. Horsnell. Bacteriological Water Quality of Wheatley Harbour and Muddy Creek, 1973. Ontario Ministry of the Environment, Internal Report. 1978.

BACTERIOLOGICAL WATER QUALITY OF  
LEAMINGTON BEACH AND PIGEON BAY, 1973

G. JENKINS, M. YOUNG AND  
G. HORSNELL.

MICROBIOLOGY SECTION  
LABORATORY SERVICES BRANCH  
MINISTRY OF THE ENVIRONMENT

APRIL 1978

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ABSTRACT

Two bacteriological surveys of the Leamington Beach-Pigeon Bay area of Lake Erie were carried out in June and August of 1973. Extremely high bacterial densities were observed during each survey ( $>60,000$  total coliform/100 ml at the outfall from the Water Pollution Control Plant), and the water quality of Pigeon Bay appears to be severely degraded due to the inadequate treatment of wastes from the canning industries.

## INTRODUCTION:

Pigeon Bay is located in the north-western area of Point Pelee, south of Leamington, Ontario. The region has many small canning industries, and is a popular recreational area. There are many cottages along the Point Pelee shoreline, and swimming, diving and boating are regular activities along the beaches.

The waters of the bay are also receiving waters for the effluent from the local Water Pollution Control Plant (W.P.C.P.) and the local canning industries.

Two surveys were carried out during the summer of 1973, in order to assess the impact of the W.P.C.P. and canning industry effluents on the waters of Pigeon Bay. One survey was carried out in June, prior to the peak canning period, while the other was carried out in August during the peak canning season.

The studies indicate that there is substantial degradation of the water quality of Pigeon Bay due to overloading of the waste treatment facilities during the peak canning season.

## Methods:

### Field Procedures:

Two surveys were conducted during the summer of 1973, the first from June 19-21, the second from August 14-16.

Samples were collected once daily for three consecutive days from 28 surface stations, and 11 depth stations. In addition, a station at the mouth of Sturgeon Creek, a station

adjacent to the W.P.C.P. outfall, and a station at the mouth of the Selkirk drain, were sampled five times daily.

The samples were collected in sterile 237 ml rubber air syringes using a modified piggy-back sampling device. Surface samples were collected approximately 1.5 metres below the water surface, while depth samples were collected at the mid-hypolimnion. The samples were immediately put on ice and transported to the M.O.E. regional laboratory in London for analysis.

#### LABORATORY METHODS:

All samples were analyzed within twenty-four hours of the sampling time, and were analyzed for total coliforms (TC), fecal coliforms (FC), and fecal streptococci (FS). Counts were recorded as number of organisms per 100 ml.

Membrane filtration methods were performed according to Standard Methods (13th edition)(1), using M-endo Agar LES (Difco) for TC. MacConkey Membrane Broth (Oxoid) for FC, and M-enterococcus Agar (Difco) for FS.

#### STATISTICAL METHODS:

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean. The large amounts of data generated from these surveys require that statistical methods be utilized to summarize the results concisely and to facilitate an unbiased interpretation.

Once the station group statistics had been obtained, an analysis of variance program (ANOVA) was used to group the stations into areas within the same statistical bacterial level. The ANOVA analyses were first performed on all survey stations. If the calculated F-ratio was less than the critical F-ratio (0.05 level), the stations were considered statistically the same and were summarized as a group with one set of overall group statistics. At the same time as the ANOVA analyses were performed, the homogeneity of the variance was also checked using Bartlett's  $X^2$  test of homogeneity. If either the F or  $X^2$  values were significant, then stations were withdrawn until both were non-significant. The statistics were then repeated on the withdrawn stations until all stations had been properly grouped.

Criteria:

The criteria considered permissible for public surface water supplies when full treatment is supplied for the three sanitary indicator bacteria; total coliforms, fecal coliforms, and fecal streptococci are a maximum geometric mean of 5000, 500, and 50 per 100 ml respectively. The maximum permissible levels for private water supplies requiring chlorination only are 100, 10, and 1 per 100 ml respectively, while that for waters requiring chlorination and filtration are 400, 40, and 4 per 100 ml.

The Recreational Use Criteria states that "Where ingestion is probable, recreational waters can be considered impaired when the coliform, fecal coliform, and/or enterococcus geometric mean density exceeds 1000, 100, and/or 20 per 100 ml respectively...". The geometric mean of the FS results is

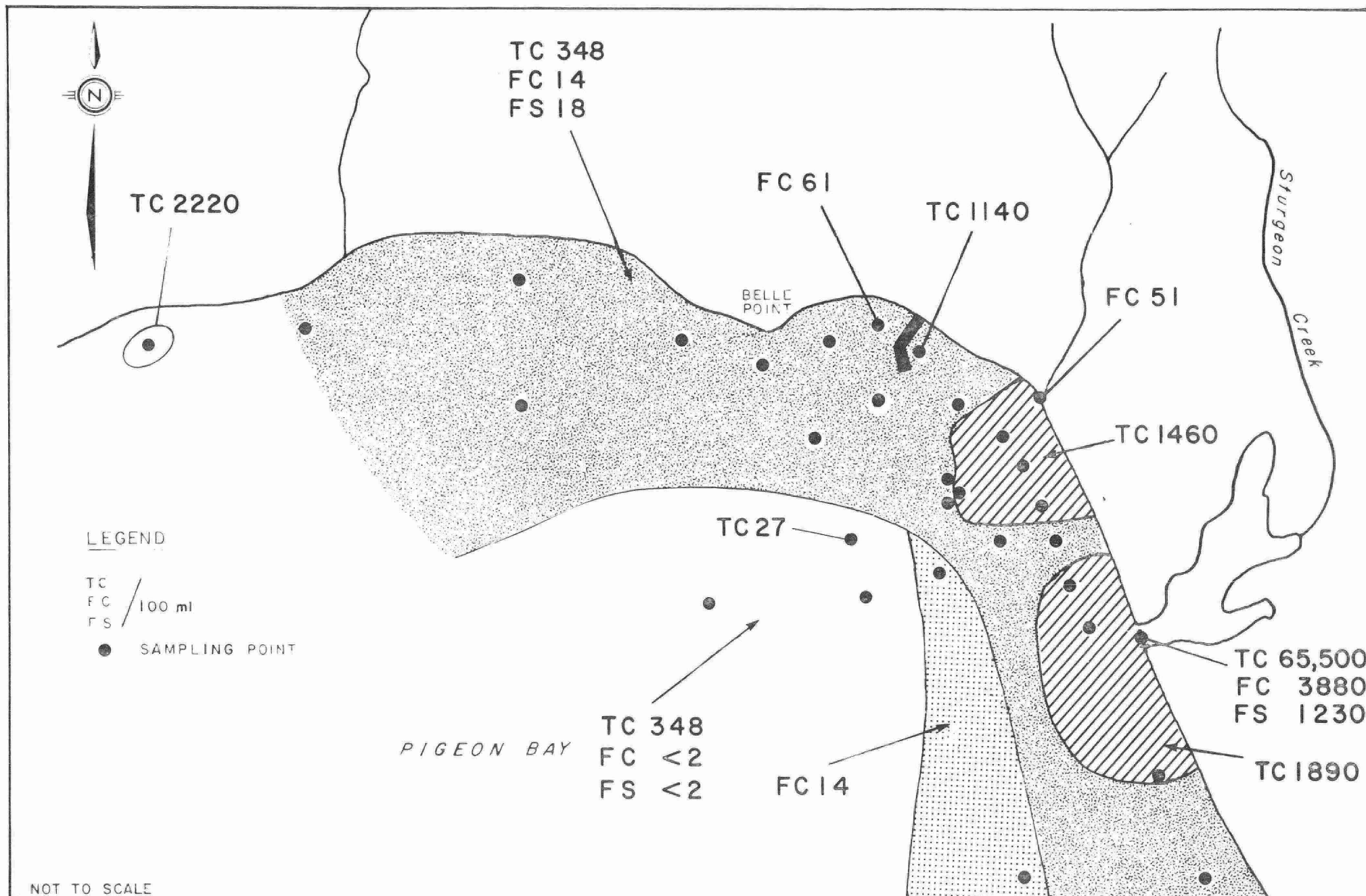
mainly used in a ratio with the corresponding FC geometric mean (FC/FS) to gain information on the source (human or non-human) of pollution within areas adjacent to or at an input. If this ratio is greater than 4.0, the source is most likely of human origin (2). It should be noted that this ratio is used to determine the source of pollution and not the safety of the water as animals are a potential source of organisms pathogenic to humans.

#### Results:

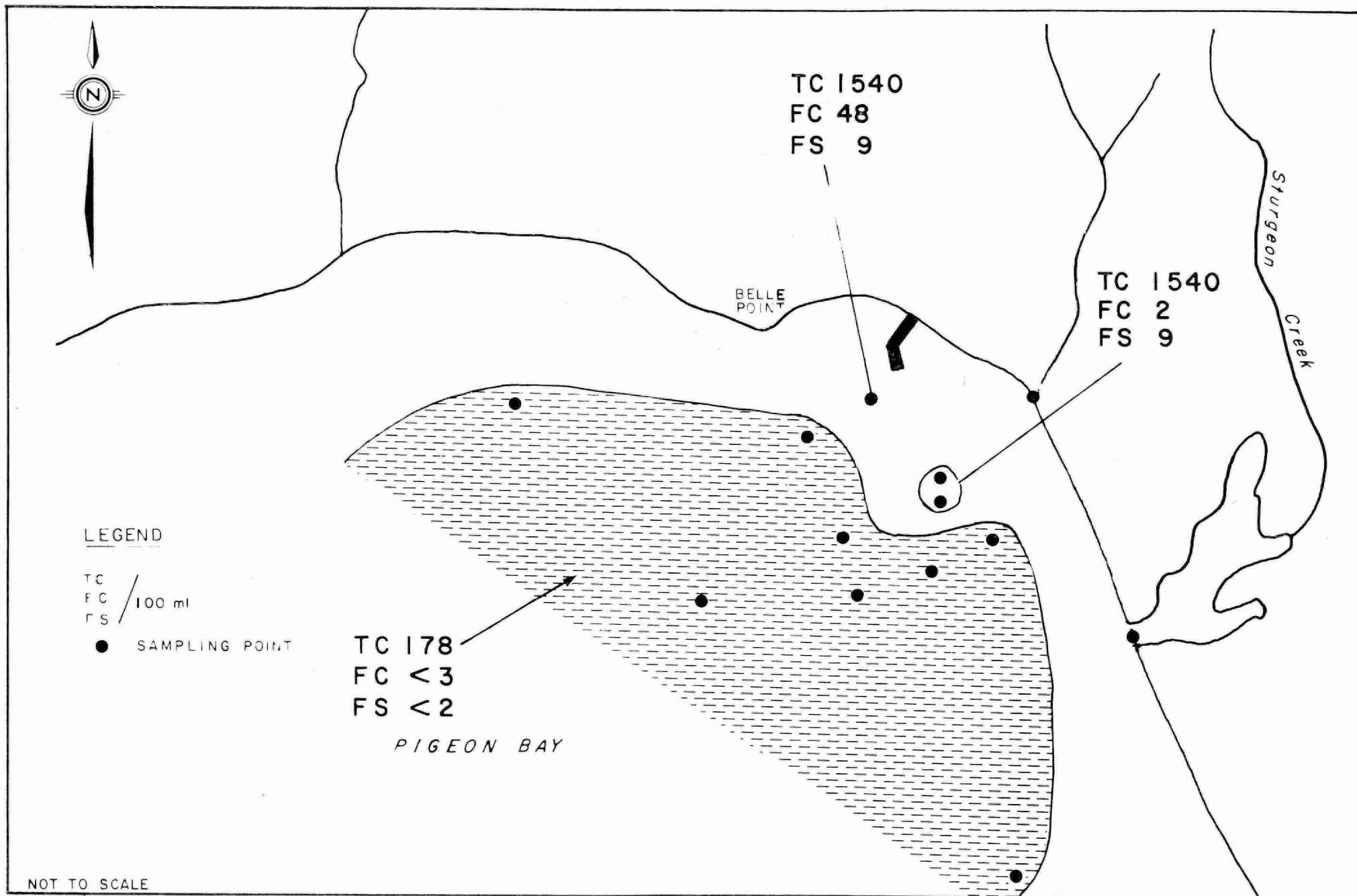
During June, most of the nearshore waters stretching southeastward from the Leamington Pier past the mouth of Sturgeon Creek exceeded the Recreational Use Criteria for total coliforms (see Map 1). The FC and FS levels in this area were generally well within these limits, with the exception of the mouth of Sturgeon Creek, where TC, FC, and FS levels were 65500, 3880, and 1230/100 ml respectively. The major portion of the nearshore waters had FC and FS levels of 14 and 18/100 ml respectively, while the outermost stations sampled had FC and FS levels < 2/100 ml.

The depth stations adjacent to the W.P.C.P. outfall had a TC level of 1540/100 ml, while the rest of the surveyed area had low levels for all three parameters (Map 2).

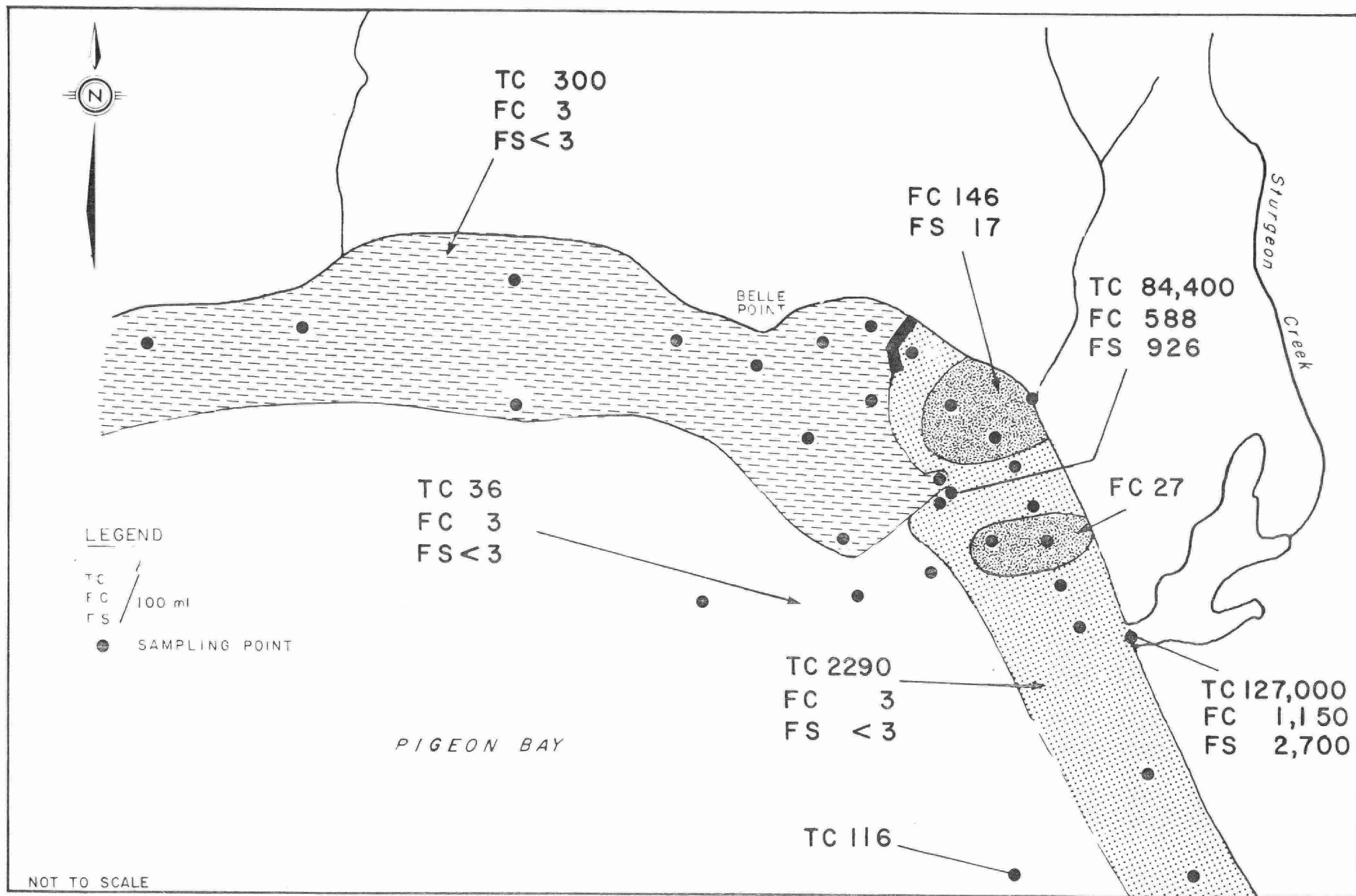
During the August survey, the TC, FC, and FS levels adjacent to the W.P.C.P. outfall were 84400, 588, and 926 respectively (see Map 3). The entire shoreline area from the Leamington pier southeastward past Sturgeon Creek had a TC concentration of 2290/100 ml. The mouth of Sturgeon Creek was once again the most heavily polluted region with TC, FC, and FS levels of 127000, 1150, and 2700/100 ml respectively.



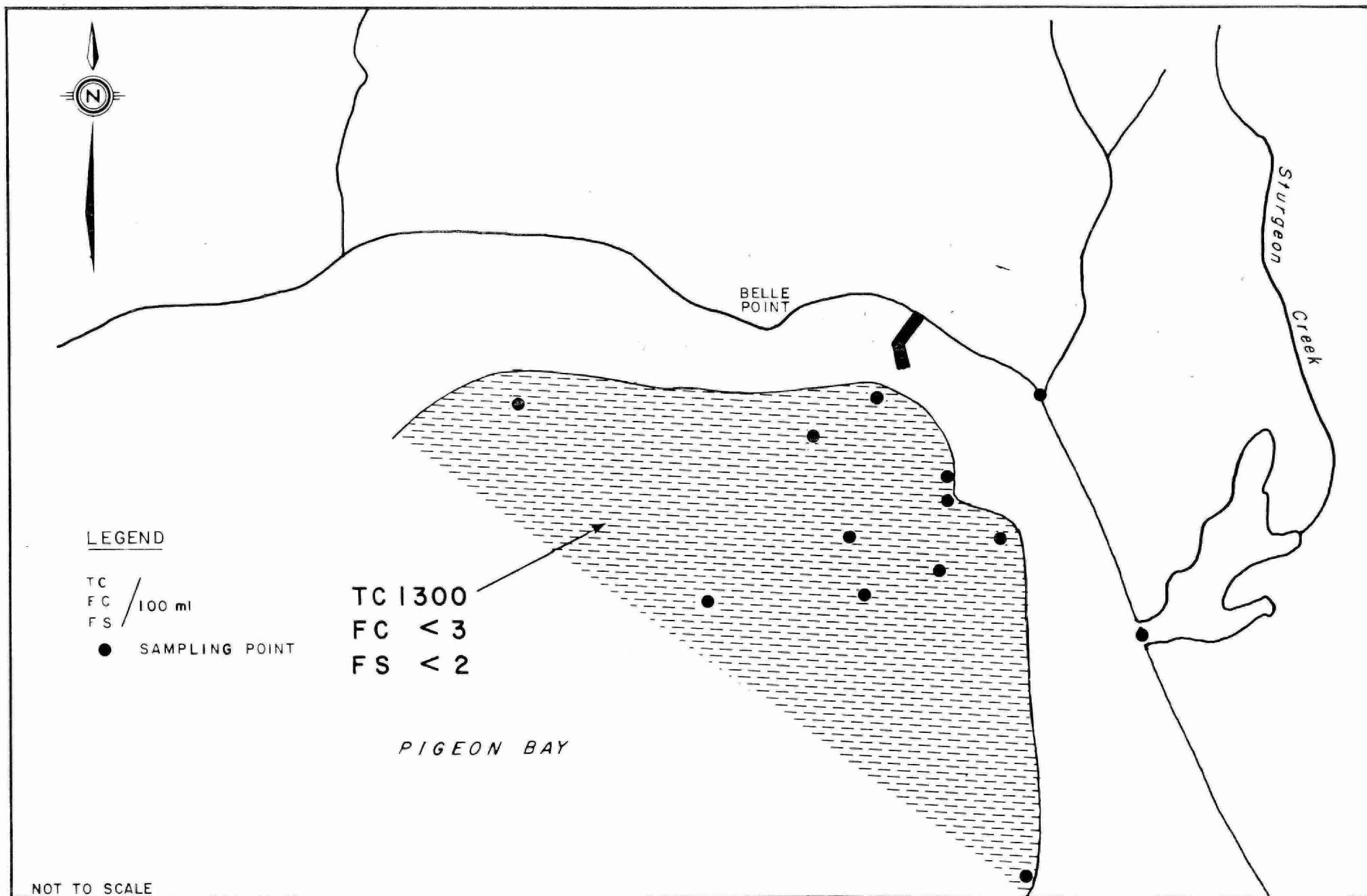
MAP 1 : PIGEON BAY - MICROBIAL DENSITIES (SURFACE), JUNE, 1973



MAP 2 : PIGEON BAY - MICROBIAL DENSITIES (DEPTH), JUNE 1973



MAP 3 : AUGUST 1973 - SURFACE



MAP 4 : AUGUST 1973 - DEPTH

West of the Leamington pier, the TC, FC, and FS levels were well within criteria limits.

The depth bacterial concentrations were uniform throughout the survey area, with a TC level of 1300/100 ml and FC and FS levels <3/100 ml. (Map 4).

#### Discussion:

The greatly elevated bacterial levels around the W.P.C.P. outfall during the August survey indicate the inadequacy of the treatment procedures during peak load times. In June, the TC levels around the outfall had exceeded the recreational use criteria, but the FC and FS levels were relatively low. However during the August survey, the levels of all three bacterial parameters were significantly elevated above the recreational criteria limits. Consequently, all of the area surveyed south-east of the Leamington pier was degraded to an extent that would make body-contact recreational use hazardous.

The mouth of Sturgeon Creek exhibited extremely high TC, FC, and FS levels during both surveys. The primary source of this contamination appears to be waste from one or more canning operations that dispose of their effluent into the creek.

The findings of this survey indicate the need for improved treatment facilities for both municipal and industrial waste in this region. The H.J.Heinz Co. provided secondary treatment for its waste, while the municipal W.P.C.P. only provided primary treatment for the municipal waste and for the effluent from the Pyramid Canning Co., and was obviously overloaded during peak canning season.

ReferencesL

1. Standard Methods for the examination of Water and Wastewater, 13th Edition. 1971. Edited by M.J. Tarus, A.E. Greenberg, R.D. Haok and M.C. Rand. A.P.H.A. AWWA. W.P.C.F. pp. 635-693.
2. Geldreich, E.E. and Kenner B.A. 1969. Concepts of fecal streptococci in stream pollution. Journal W.P.C.F. 41 R. 336-R 352.

BACTERIOLOGICAL WATER QUALITY OF  
WHEATLEY HARBOUR AND MUDDY CREEK, 1973.

G.D. JENKINS, M. YOUNG  
AND G. HORSNELL

MICROBIOLOGY SECTION  
LABORATORY SERVICES BRANCH  
ONTARIO MINISTRY OF ENVIRONMENT.

JULY 1978.

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## ABSTRACT

A survey was carried out in June, 1973, to assess the microbial water quality of Wheatley Harbour and Muddy Creek. Extremely high total coliform, fecal coliform, and fecal streptococcal densities were found, particularly adjacent to the outfall from Omstead Fisheries.

## INTRODUCTION:

Wheatley Harbour is situated at the mouth of Muddy Creek, which flows into Lake Erie on the eastern side of Point Pelee. Muddy Creek is the receiving water for wastes from two major industries. Omstead Fisheries Ltd., and Getty Fisheries Ltd.

A survey was carried out in June 1973 to study the bacteriological water quality of Muddy Creek and Wheatley Harbour. Very high levels of all sanitary indicator bacteria were found throughout Wheatley Harbour.

## Methods:

### Field Procedures:

The area surveyed contained 19 sampling points that were sampled twice daily from June 12-14, 1973. Nine of them were within Wheatley Harbour while 10 were located in Lake Erie adjacent to the harbour mouth (Map 1).

Samples were collected 1.0 metre below the surface of the water in sterile 237 ml rubber air syringes. The samples were kept on ice until analyzed, and all samples were analyzed by membrane filtration within 24 hours of sampling

### Laboratory Methods:

For a complete description of the methods used, see the Laboratory Methods section of the Lake Erie 1973 report (1).

### Statistical Methods:

For a complete description of the statistical methods employed, see the Statistical Methods section of the Lake Erie report (1).

## RESULTS:

The highest bacterial levels were found well upstream from the mouth of Wheatley Harbour, in the vicinity of the outfall from Omstead Fisheries (Map 2). From this region, bacterial levels declined slowly throughout the harbour, and then dropped abruptly outside the harbour mouth.

At the time of this survey, all waters within Wheatley Harbour had bacterial levels exceeding those permissible for public surface water supplies and recreational use.

## DISCUSSION AND CONCLUSIONS:

Extremely high levels of all three bacterial parameters were located near the outfall from Omstead Fisheries. The outfall is probably the source of most of these bacteria, although how much it contributes is not apparent from this survey, as the bacterial levels in the waters of Muddy Creek above the outfall were not determined. However, the bacterial densities right at the outfall were the highest found in the survey area, with greater than 100,000 TC, 5200 FC and 7900 FS/100 ml being found in the effluent. These organisms probably accumulate in the intestinal cavities of fish and are released in great numbers when the fish are processed(2).

The bacterial levels upstream from the Omstead outfall were not determined, but Muddy Creek drains a great deal of agricultural farmland, and the magnitude of the microbial input from this source is unknown, but it is probably quite substantial.

The low FC/FS ratio at the outfall suggests the main source of the bacterial pollution is non-human, from animal and agricultural waste rather than from human fecal matter.

The waters of Lake Erie outside Wheatley Harbour are relatively clean and the bacterial densities are only moderately elevated above the normal values for the shoreline in this area(1).

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1. Jenking, G.D., G. Horsnell and M. Young. Bacteriological Quality of Lake Erie Nearshore Water, 1973. Internal Report. Ontario Ministry of Environment, 1978.

BACTERIOLOGICAL WATER QUALITY OF THE  
GRAND RIVER  
AUGUST 1975, MAY AND AUGUST 1976.

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APRIL 1978.

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## ABSTRACT

Bacteriological samples were collected and analyzed from the mouth of the Grand River and selected areas from Connor bay in August 1975 and from Splatt and Connor Bays in May and August 1976.

The results from the three surveys indicated poorer water quality in areas close to and at the mouth of the river than in the remaining sampling areas further removed from the mouth.

Bacterial concentrations generally remained below the Ministry of the Environment Recreational Use Criteria. During the August 1975 and 1976 surveys fecal streptococci levels were somewhat elevated at, and slightly upstream of the river mouth.

INTRODUCTION:

These surveys were carried out as part of the Ontario Ministry of the Environment regular monitoring of Great Lakes water quality, and to determine the extent of impact the Grand River has on Lake Erie. The river empties directly into Lake Erie by Port Maitland (about 40 miles west of the Niagara River).

The town of Dunnville is situated along the east bank of the Grand River and approximately 5 miles upstream from the river mouth.

## METHODS:

### a) Field

The August 1975 monitoring of the Lake Erie - Grand River area comprised 26 stations (Fig.1) while the May and August 1976 surveys comprised 27 stations (Fig.2). During both years samples were taken in the middle of the river near its mouth (15-002), others at the mouth itself (15-016), and the remaining at selected intervals in the lake. The 1976 survey area did not extend as far south into Connor Bay as did the 1975 survey but instead, additional samples were taken from Splatt Bay and the eastern periphery of the river mouth (South of Port Maitland).

In 1975, depth samples were taken at stations 15-016, 15-002 and 1054 only by means of a modified "piggy back" sampler and sterile 237 ml evacuated rubber syringes. Surface samples were collected at all stations in 175 ml sterile glass bottles. All samples were stored on ice until they arrived at the mobile laboratory in Dunnville within 6 hours of sampling.

In 1976 all samples were surface samples and were sent to the Toronto lab for analysis.

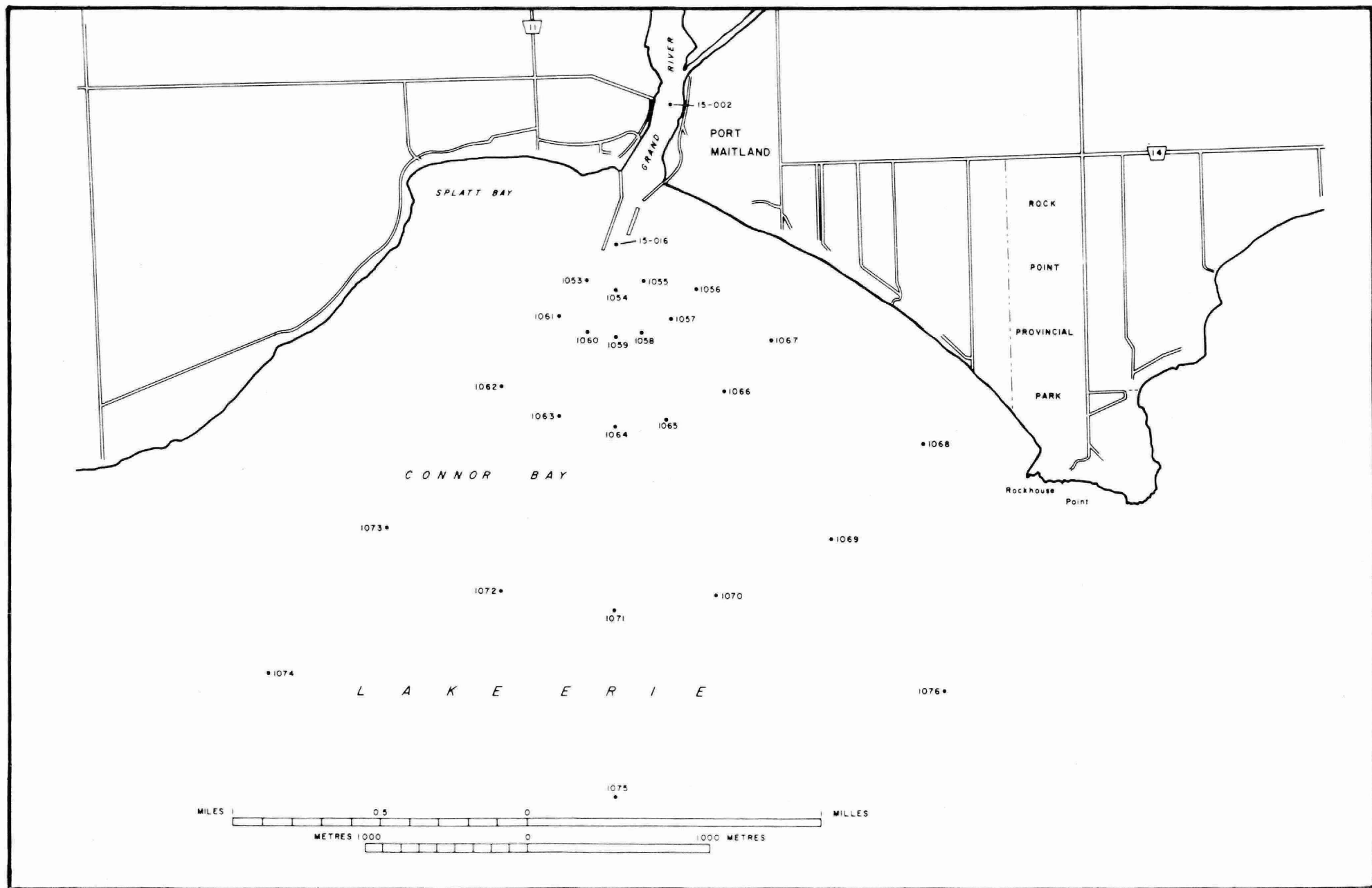


FIGURE 1 : LAKE ERIE - GRAND RIVER 1975 SAMPLING STATIONS

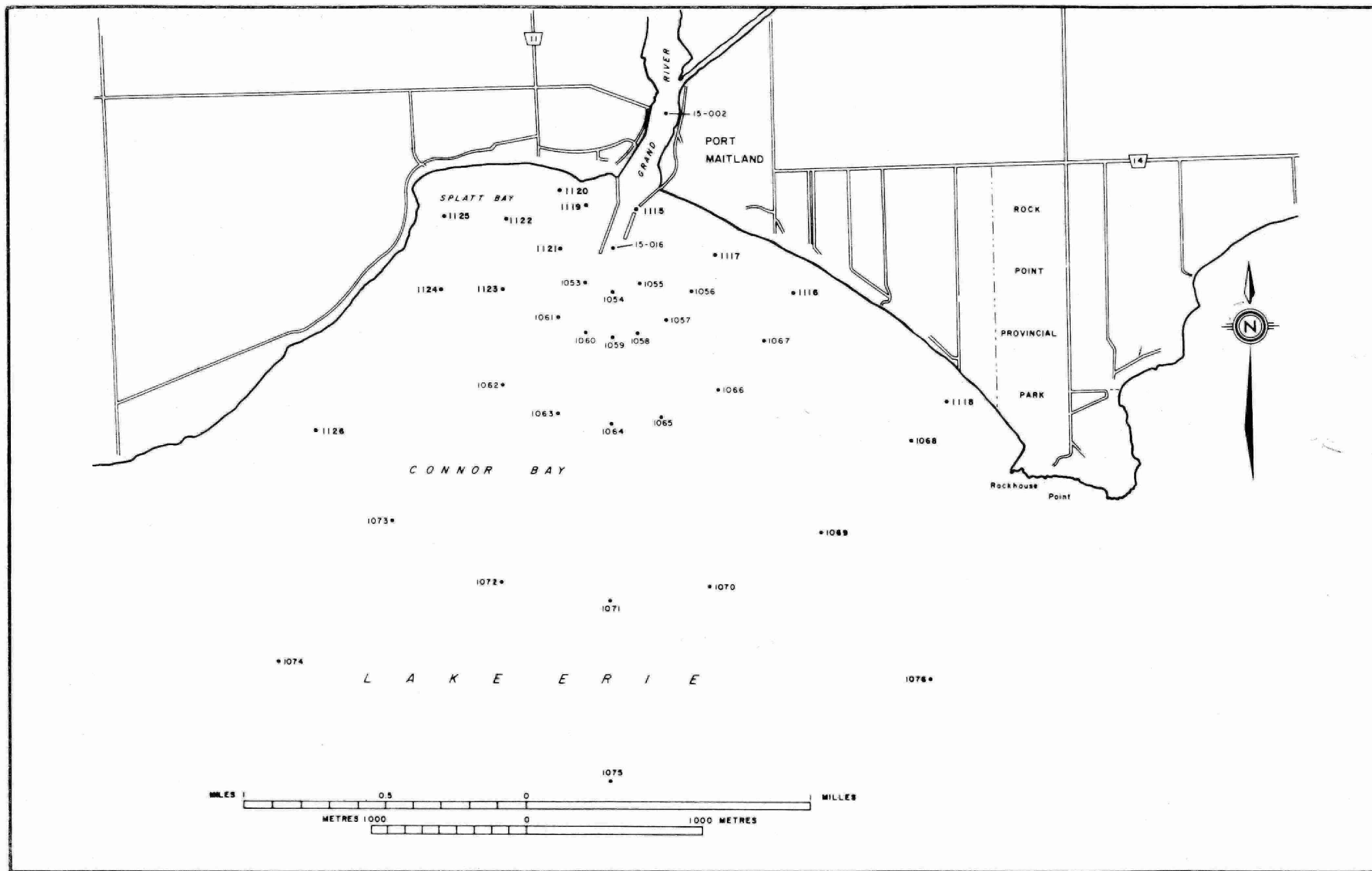


FIGURE 2: LAKE ERIE - GRAND RIVER 1976 SAMPLING STATIONS

### Lab Procedures:

All depth samples were transferred aseptically to sterilized 250 ml polycarbonate bottles. Analysis for total coliforms (TC), fecal coliforms (FC), and fecal streptococci (FS) using the membrane filtration (MF) technique as described in Standard Methods (2) were performed using m-Endo agar Les (Difco) for TC and MacConkey membrane broth (Oxoid), along with an incubation period of 18 hours, for FC determinations.

In 1975 Heterotrophic bacterial (HB) populations were determined by a spot plate technique (Bousfield, Smith and Truemann, 1974). (3) on modified Foot and Taylor Agar (appendix I) at 20°C for seven days, whereas in 1976 this medium was replaced by a Casein, peptone and starch (CPS) medium (appendix 2). Pseudomonas aeruginosa (P.aer) densities were determined using the MF procedure of Levin and Cabelli (mPA) (4). The incubation was at 41°C for 48 hours (Levin and Cabelli, 1972).

### Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is representative of a specific sample location or sampling area. The most appropriate mean for bacterial levels and this type of data is the geometric mean (GM). Statistical methods were used to summarize the results concisely and to reduce bias in the interpretation of the data. An analysis of variance programme (ANOVA) was used to summarize the data. In this programme the calculated F ratio must be less than the critical F ratio (0.05 level) in order that stations be accepted as a statistically similar group. If the F was significant, then those stations at the river mouth and in the

lake with significantly different GM's were deleted from the overall group to yield a group with similar means.

Stations comprised a group provided they were not separated by any geographic barrier, that the variances of all the stations were similar (Bartlett's Test of Homogeneity) and that the data were normally distributed. Using the ANOVA program again, calculations were done on the deleted stations until they formed a homogeneous group. This process was repeated until all possible groups were formed.

## Results and Discussion

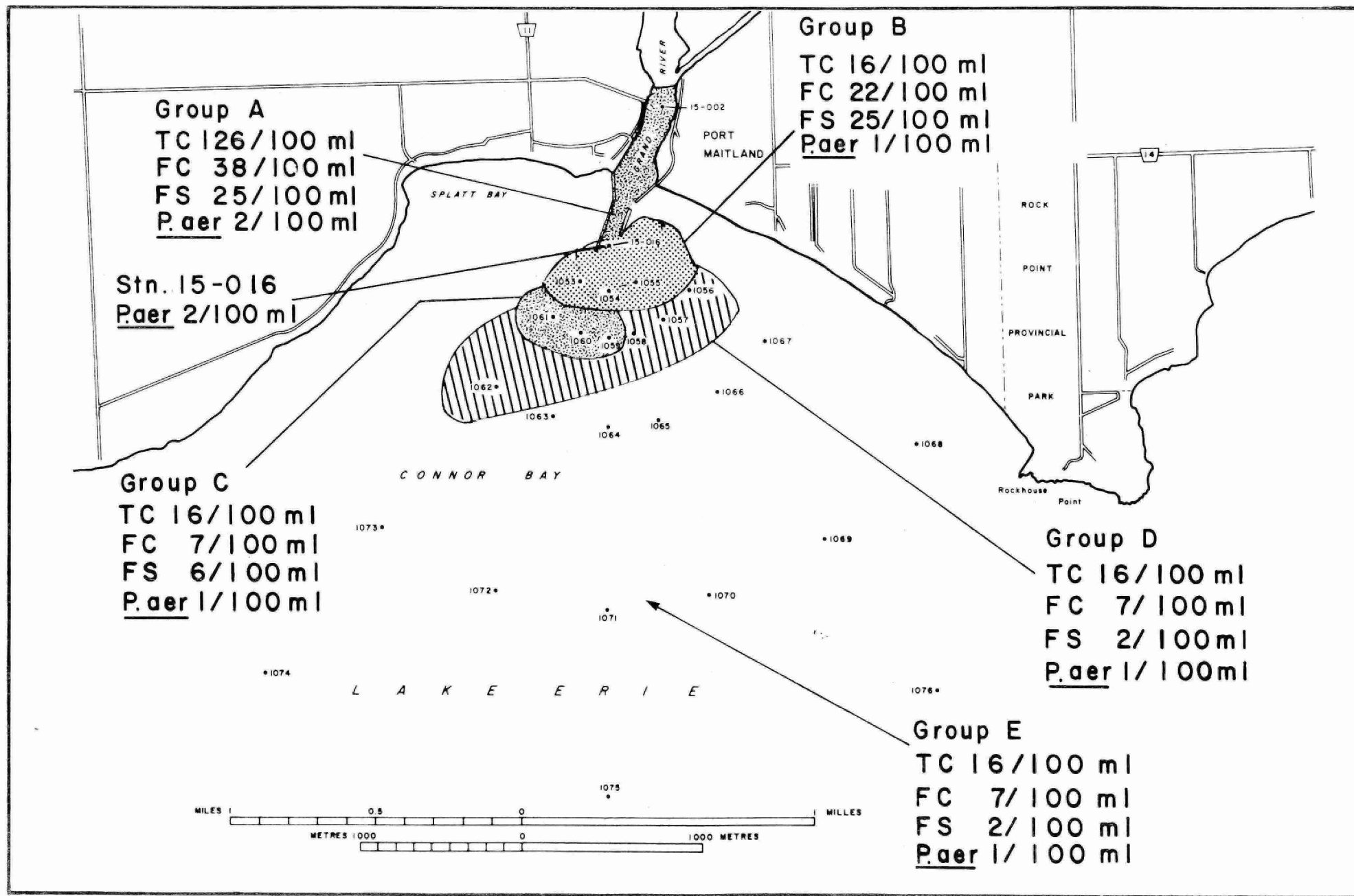
Both the 1975 and 1976 results demonstrated that the Grand River contributed to bacterial levels in Lake Erie, around the river mouth and these were higher than in areas closer to the open body of the lake.

The river mouth area in Aug.'75 (Map 1, GRP.A) had 126 TC and 38 FC/100 ml while this area in Aug.'76 had TC and FC densities that were double that of the 1975 survey (Map 4, GRP.B: 254 TC and 76 FC/100 ml.) These levels were within the MOE Recreational Use Criteria and the ratio of FC to FS suggested contamination from combined human and non-human sources.

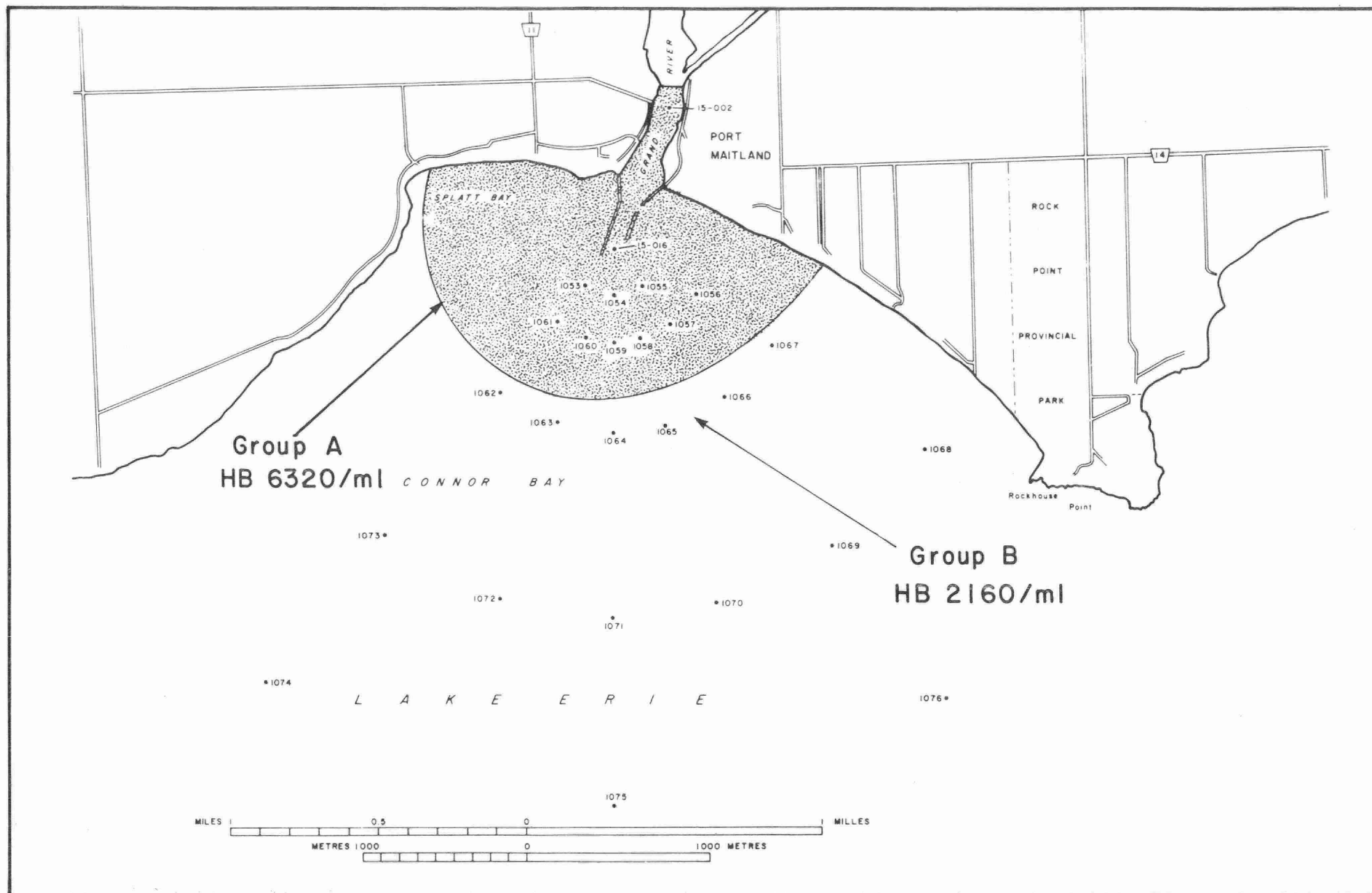
The Pseudomonas aeruginosa density increased 6/100 ml in the May 1976 survey (Map 3, GRP. A) from 2 P.aer/100 ml and 1 P.aer/100 ml the previous year in the vicinity of the river mouth and remaining sampled areas respectively (Map 1), and is indicative of water quality deterioration. Although no criteria has yet been established for this parameter, its presence in water could constitute a major health hazard since it is indicative of a local or recent source of fecal pollution of serious concern to users of waters for consumption or recreational purposes.

The change in media from modified Foot and Taylor in 1975 to CPS in 1976 was made to improve bacterial recoveries. This negates the use of a statistical comparison between the two years.

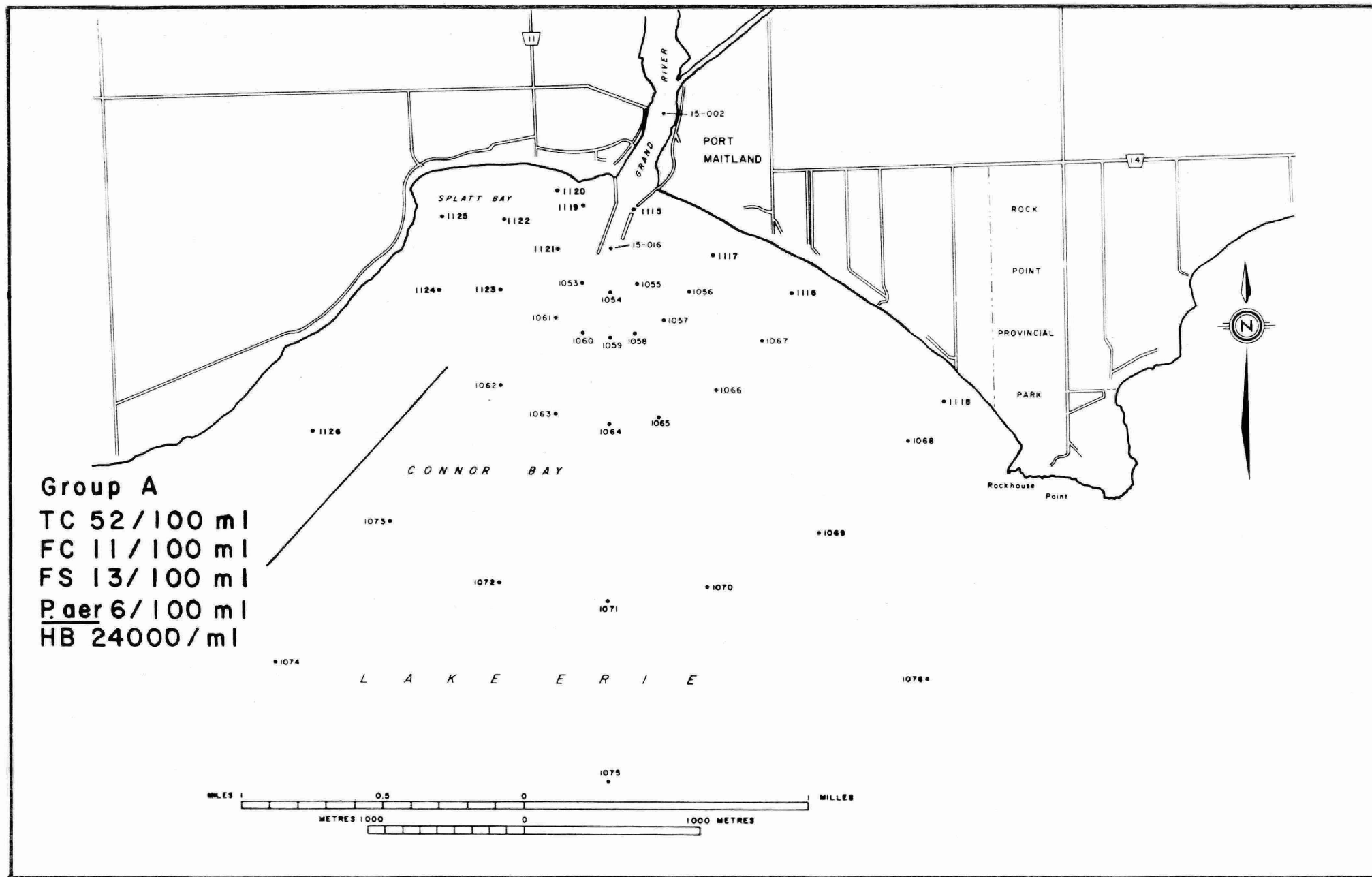
However the tenfold increase in HB from 1975 to 1976 cannot be accounted for by the change in media and thus would be indicative of deteriorating water quality. In 1976, HB concentrations increased from 24000 HB/ml in May (Map 3, GRP.A) to 32000 HB/ml in August (Map 4, GRP.A). This reflects a higher level of nutrient



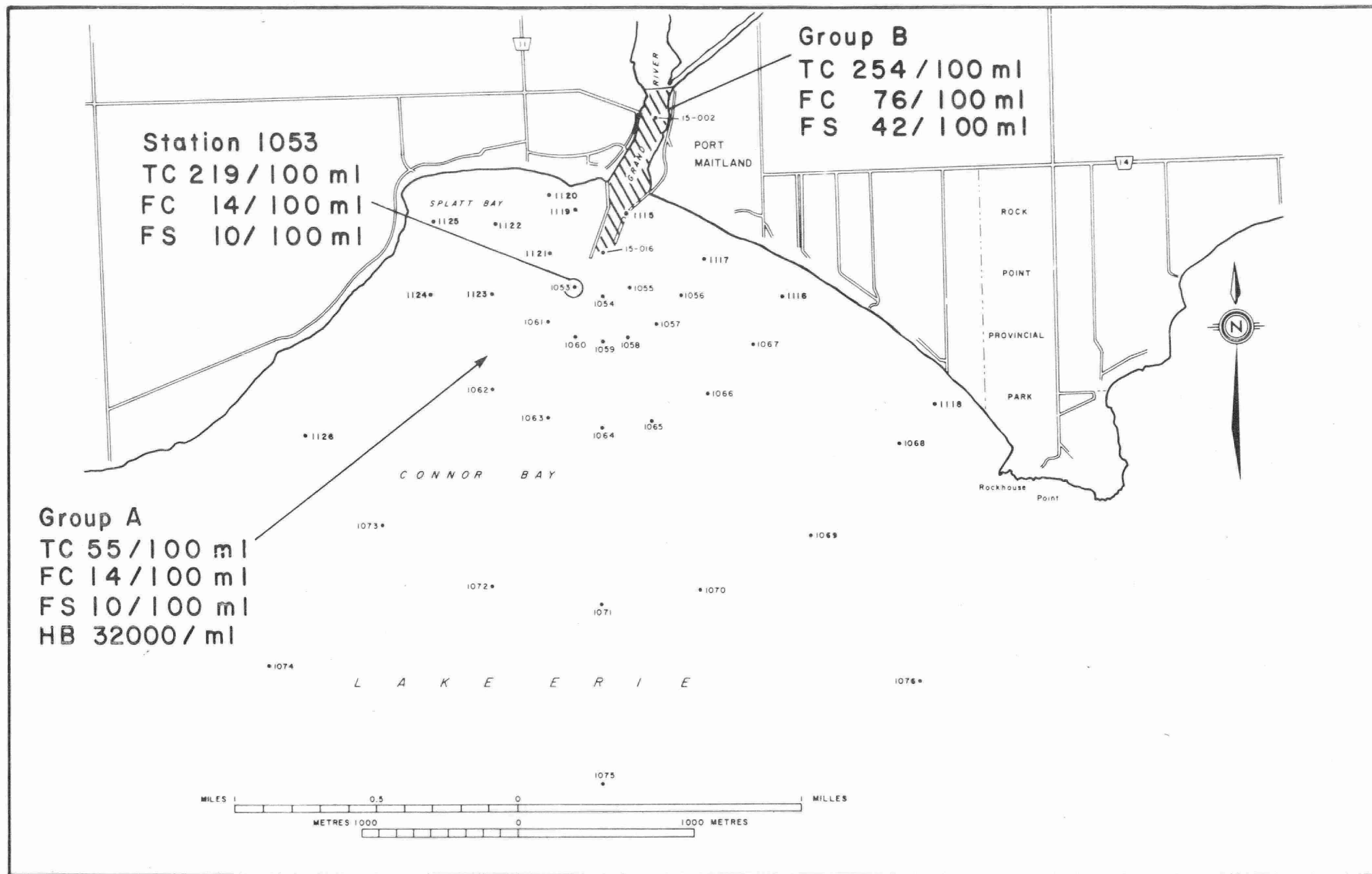
MAP 1 : DISTRIBUTION OF TC, FC, FS, & P.aer AUGUST 5-10, 1975 IN LAKE ERIE - GRAND RIVER MOUTH AREA



MAP 2 : DISTRIBUTION OF HETEROTROPHIC BACTERIA AUGUST 5-10, 1975 IN LAKE ERIE-GRAND RIVER MOUTH AREA



MAP 3 : DISTRIBUTION OF TC,FC,FS,P.aer & HB MAY 12-22,1976 IN LAKE ERIE -GRAND RIVER MOUTH AREA



MAP 4 : DISTRIBUTION OF TC,FC,FS & HB AUGUST 24-29,1976 IN LAKE ERIE - GRAND RIVER MOUTH AREA

enrichment in August probably due to the increased use of the river and lake by vacationers at that time and more favourable conditions for bacterial growth.

Summary:

The surveys demonstrated that bacterial concentrations in the Grand River are significantly higher than the surrounding lake water and thus the inflow of the river is causing a net input of bacteria to Lake Erie. Sanitary indicator bacterial (TC, FC, FS) levels were generally below the MOE Recreational Use Criteria.

Elevated FS levels of 25/100 ml and 42/100 ml were found in the river mouth area during the August 1975 and 1976 surveys respectively. The presence of P. aer. indicates a health hazard could exist in the area.

The survey design only incorporated one sampling point in the Grand River itself (15-002) and one near its mouth (15-016). More point source sample should be taken in the River if the source and impact of pollution are to be sought and abatement measures undertaken.

### References

1. Guidelines and Criteria for Water Quality Management in Ontario. (Ontario MOE July 1976, P.22-24)
2. Standard Methods for Examination of Water Wastewater 13th Edn.(1971), APHA, AWWA. WPCF pp 635-693
3. Bousfield, J.I., Smith, L.G. and Trueman, W.R. 1973. The use of semi-automated pipettes in the viable counting of bacteria. J. Appl. Bact. 36:297-299
4. Levin, M.A. and Cabelli, V.J., 1972. Membrane filter techniques for enumeration of Pseudomonas aeruginosa. Appl. Microbiol. 24, 864-870.

## Appendix I

Foot and Taylor Agar (Modified)

Peptone	0.5 g
$K_2HPO_4$	0.29
$MgSO_4$	0.59
$FeCl_3$	0.2 ml of a 0.5% Sol <sup>n</sup> .
Soluble Casein	0.5 g
Agar	20g.
$dH_2O$	1000 ml
Actidione	100 ppm

pH 7.2 Autoclave 15 min/121°C.

Appendix 2CPS AGAR

$K_2HPO_4$	0.29
$MgSO_4 \cdot 7H_2O$	0.059
Ferric Chloride Sol'n	0.2 ml of 0.5% $FeCl_3$ Sol'n
Peptone	0.59 g
Soluble casein	0.59 g
Soluble starch	0.59 g
Glycerol	1.09 g
Agar	20.0 g
$DH_2O$	1000 ml

Adjusted pH before autoclaving 7.05

Autoclave 15 min. (121°C) Final pH 7.2

100 ppm filter sterilized actidione added to reduce  
mold contamination



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